Sensitivity studies for 3rd generation LQ and RPV SUSY search

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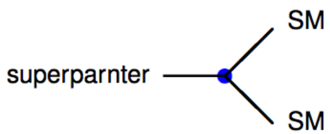
Snowmass Energy Frontier Workshop
BNL, 3-6 April, 2013

Outlook

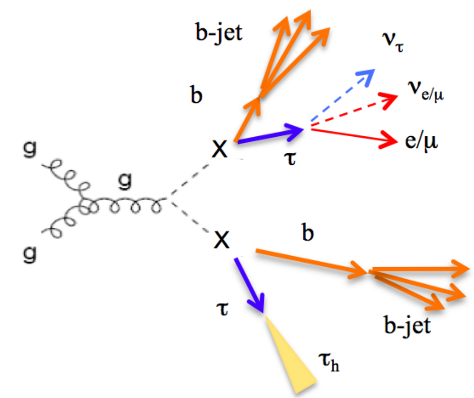
- Motivation: search for new physics in final state with tau leptons and b jets
  - Single/Vector LQ
  - RPV Stop
- Review of the previous analyses and results
- Expected performance of the object ID with PU
- Current studies and results
- Plans

Motivation

- Symmetries between leptons and quarks motivate existence of boson fields mediating lepton-quark interaction
  - GUT, Composite models – Leptoquarks
  - R-parity violating SUSY – squarks or sleptons



$$W = \frac{1}{2}\lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k + \frac{1}{2}\lambda''_{ijk} U^c_i D^c_j D^c_k$$



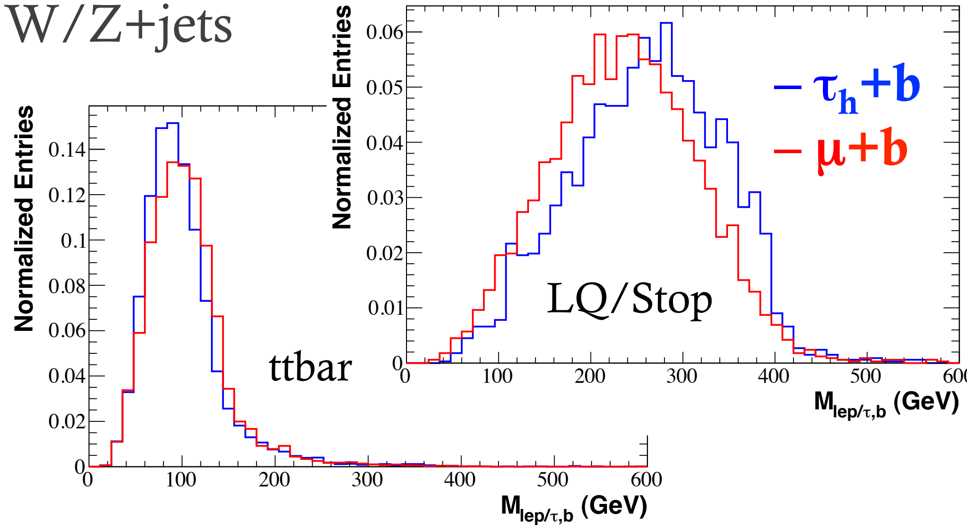
- Dominant production of pair of heavy particles is via QCD interactions
  - Cross section depends only on mass of a particle
    - Considering heavy gluino (M>1.5 TeV) scenario in SUSY

- Pair production of third generation LQ or Stops are studied
  - Signature with two τ leptons and two b jets: $e\tau_h$+2b-jets and $\mu\tau_h$+2b-jets

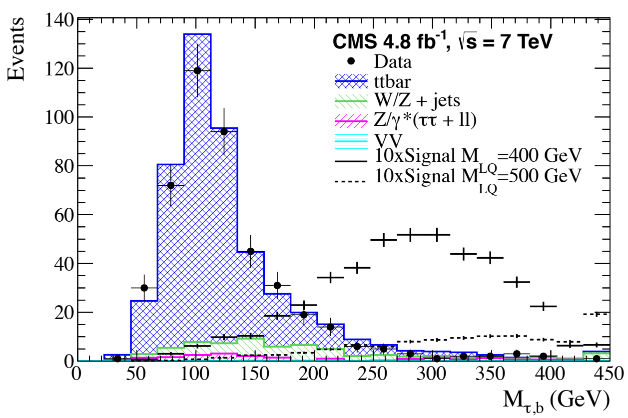
Overview of 7 TeV analysis

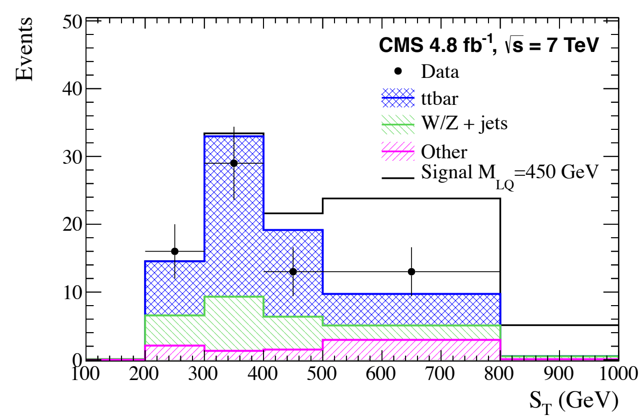
- Major backgrounds -- ttbar and W/Z+jets processes
  - Invariant mass of τ_h and b-jet

$$M = \sqrt{(E_{\tau_h} + E_b)^2 - (\vec{p}_{\tau_h} + \vec{p}_b)^2}$$



- Search for excess over the SM background in S_T distribution



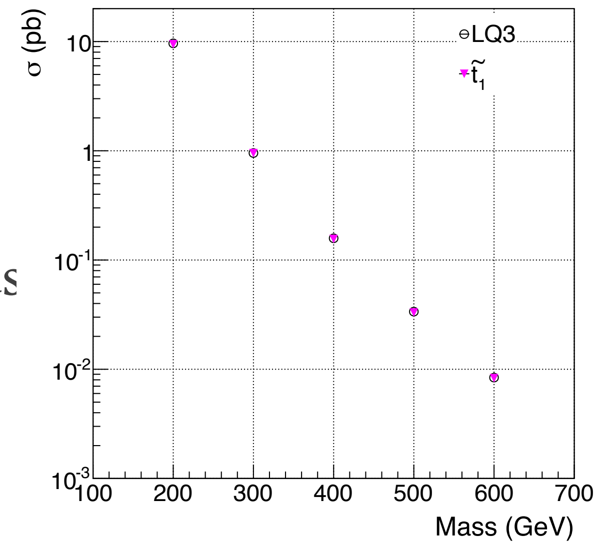


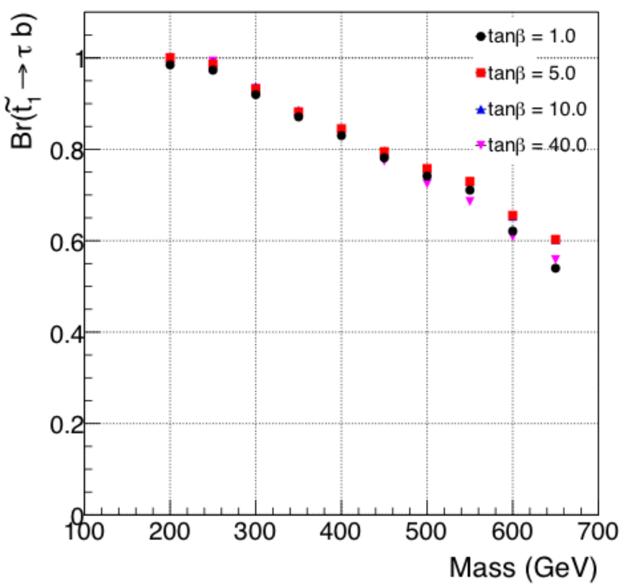
PRL 110, 081801 (2013)
arXiv: 1210.5629v1

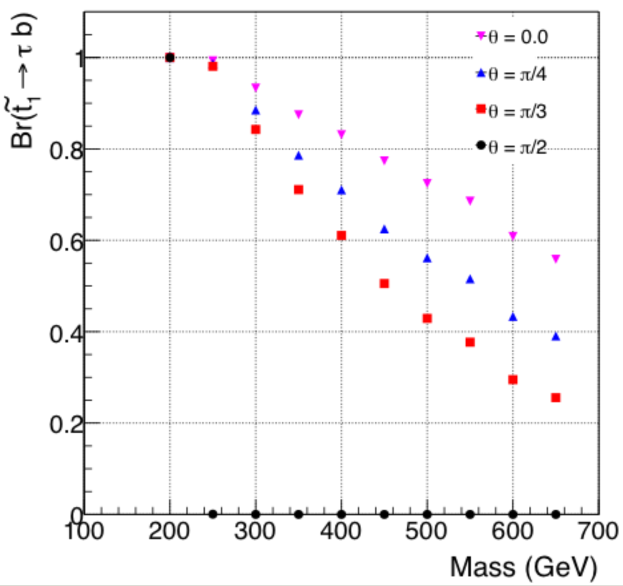
Stop vs LQ

- Cross sections agree within a couple of percent for heavy gluino scenario
  - Dependence on tan β and stop mixing angle is small

- Branching fraction is strongly dependent on various parameters: SU(2) gaugino mass M_2, Higgsino mixing parameter μ, stop mixing angle, etc.





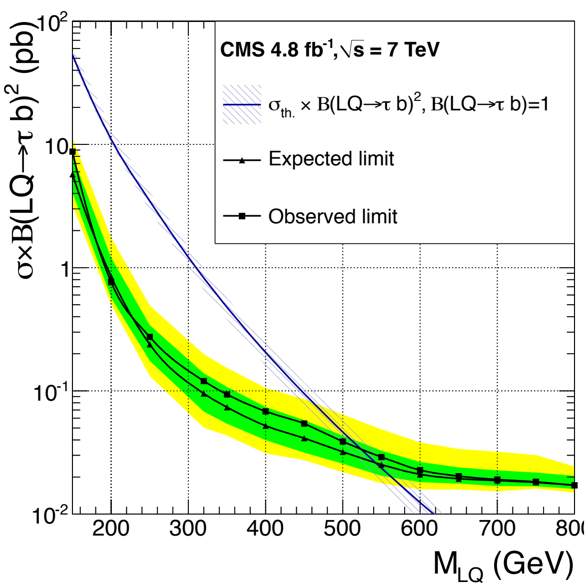


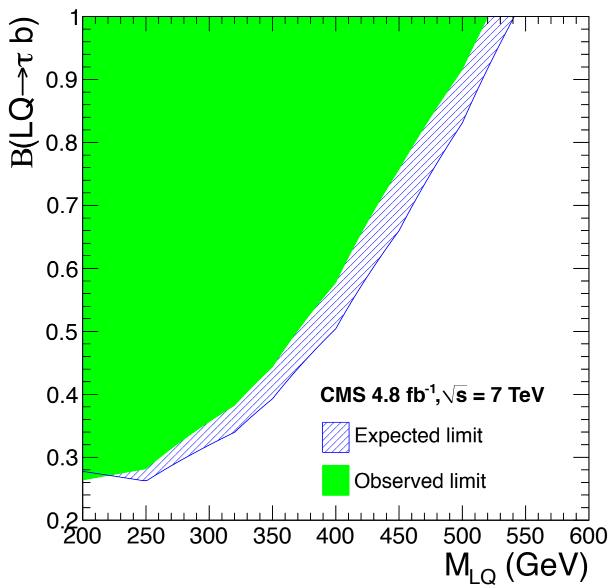
Results on LQ3/RPV Stop

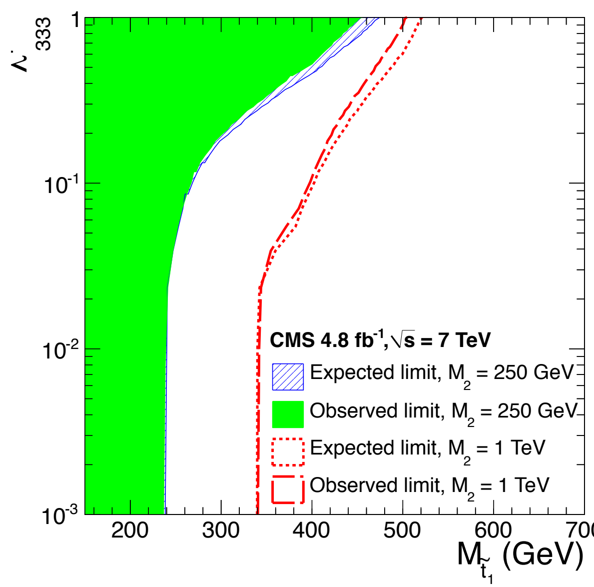
- Scalar LQ/Stops with RPV decay with masses below 525 GeV are excluded at 95% C.L.

- Limits are set on RPV coupling λ'_{333} for a given benchmark scenario

Benchmark:
- heavy or light M_2
- Higgsino mixing μ = 380 GeV
- $\tan\beta$ ~ 40 and mixing angle ~0





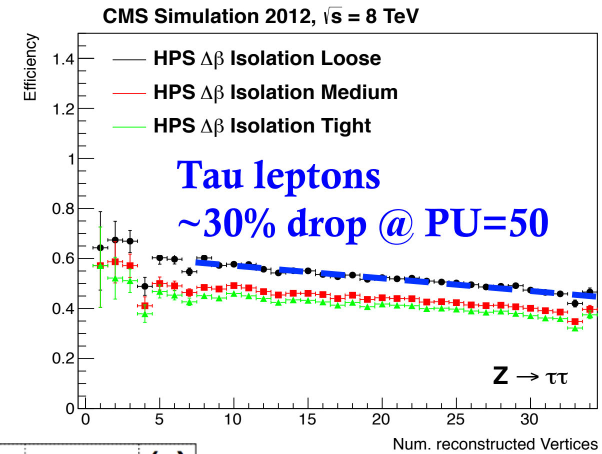


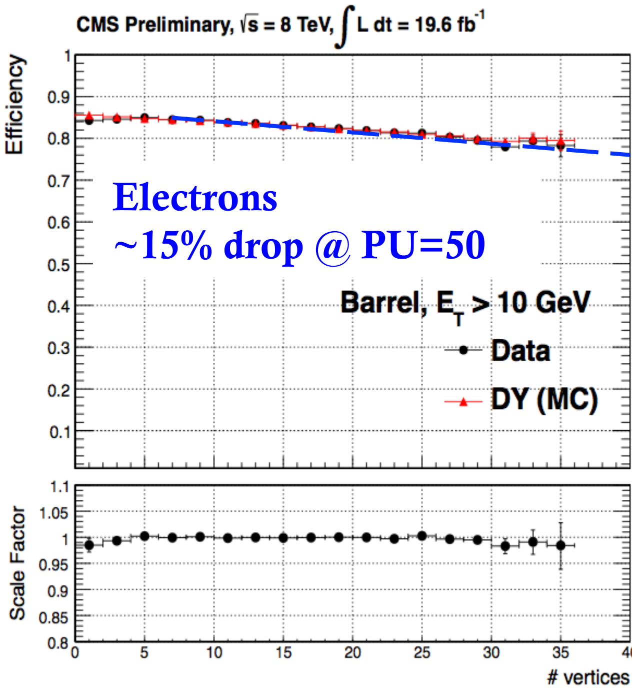
Current studies

- What higher center of mass (CM) machine can offer
  - Higher cross sections and thus a higher mass reach
  - Much higher pileup (PU):
    - Effects on the efficiency might be noticeable, but at high-p_T we expect them to be less drastic – needs checks and verification
- Outline of the current work presented today
  - Extrapolation of the reconstruction efficiencies at a particular PU scenario
    - Need for high PU Delphes samples to get more precise estimation of the expected signal efficiency (in touch with Sanjay Padhi et al.)
  - Estimation of background using lower CM and PU samples
  - Estimation of expected signal using lower PU samples at $\sqrt{s}$=14 TeV
  - Check the sensitivity with 300 fb^{-1} luminosity at $\sqrt{s}$=14 TeV
  - Things to do: plan for the next couple of months

Object ID performance

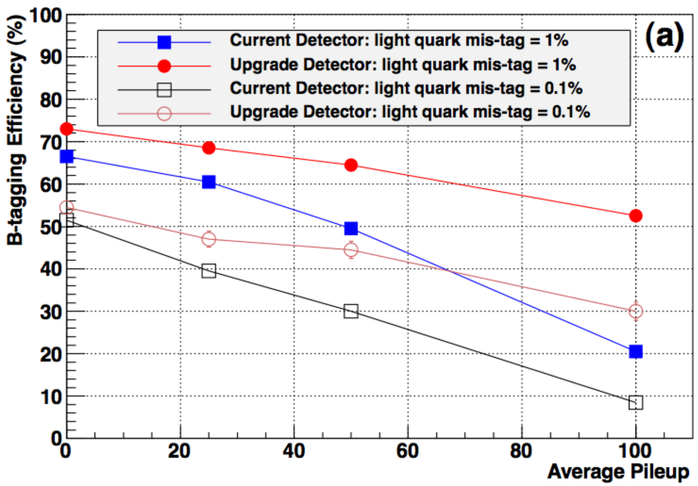
- High PU is expected to degrade capabilities to identify physics objects: leptons, hadronic tau leptons, and b-jets





b-jets

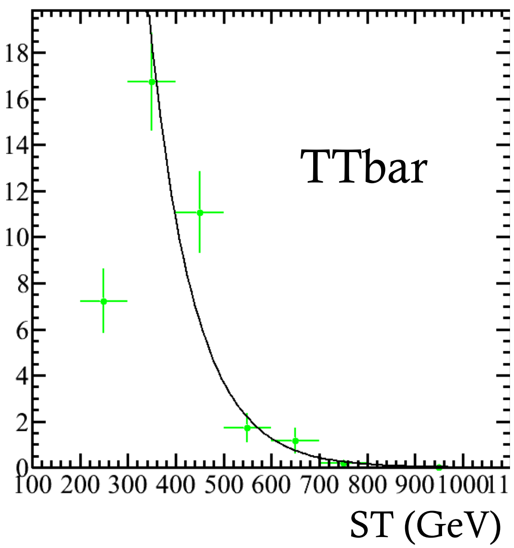
~15% drop @ PU=50

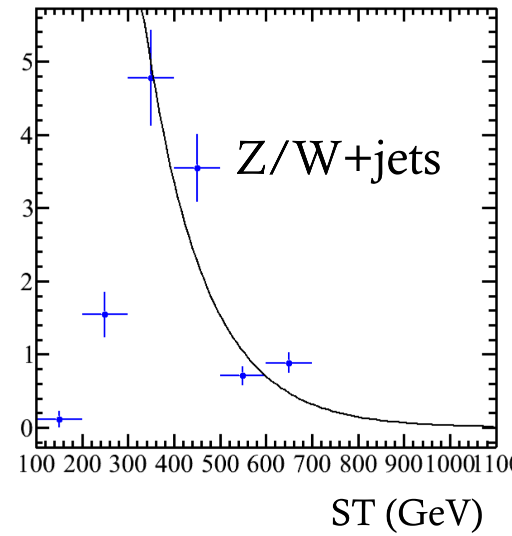


These performances are averaged over p_T → gives conservative estimate of efficiencies at high PU for heavy resonance searches

Yield Estimates

- Background samples for different scenarios are not yet available
  - Fit tail of ST distribution with an exponential function; statistical precision of the fit is propagated as systematic uncertainty on the limits
  - Extrapolate the yield to high ST region
  - Scale the yields to cross sections for 14 TeV according to *arXiv:1206.3557*





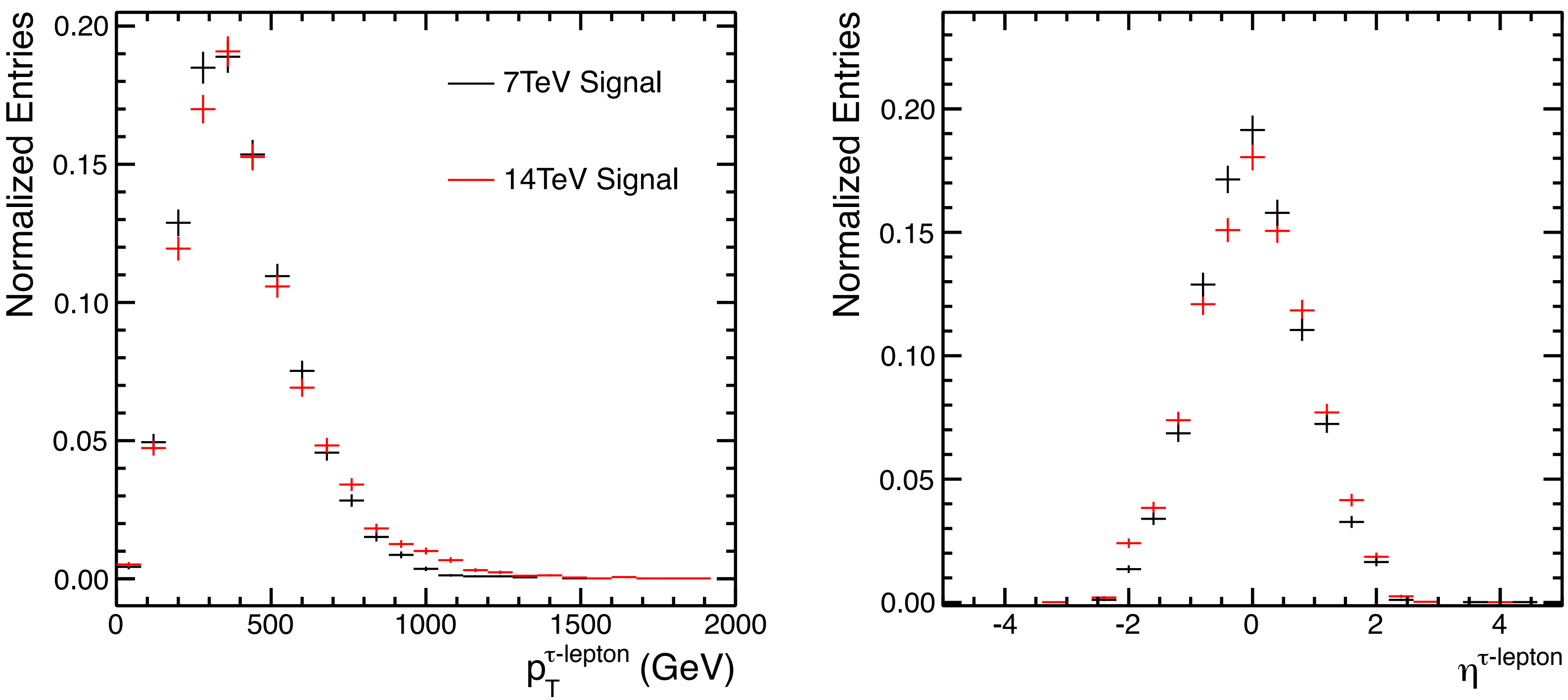
- LQ Signal sample was generated for 14 TeV with old PU scenario
  - NLO cross sections according to *arXiv:0411038, Phys.Rev.D71:057503,2005*

- The yields were estimated by counting number of signal and background events above S_T > X GeV, where X=M_{LQ}, $S_T = p_T(l)+p_T(\tau)+p_T(b_1)+p_T(b_2)$

Kinematics at 7 TeV and 14 TeV

- The NLO effects at 14 TeV are more pronounced – final state objects are expected to be more energetic and less central
  - Using the extrapolation of background yields from 7 TeV samples makes our results a bit less conservative

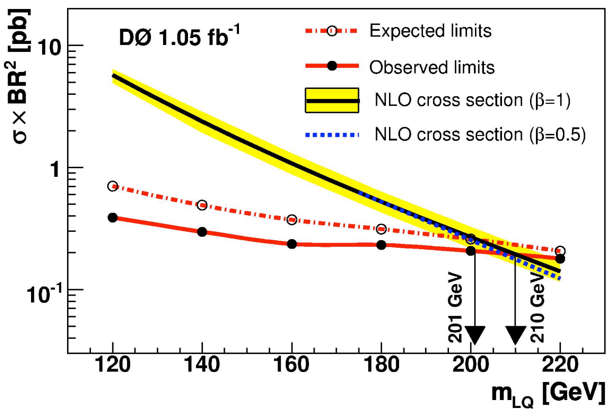
Generated quantities



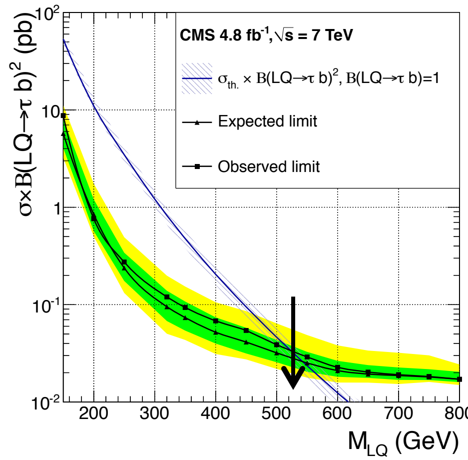
Results

- Previous results:
  - D0 with 1/fb excludes ~200 GeV masses
  - CMS with 5 /fb at 7 TeV excludes ~500 GeV

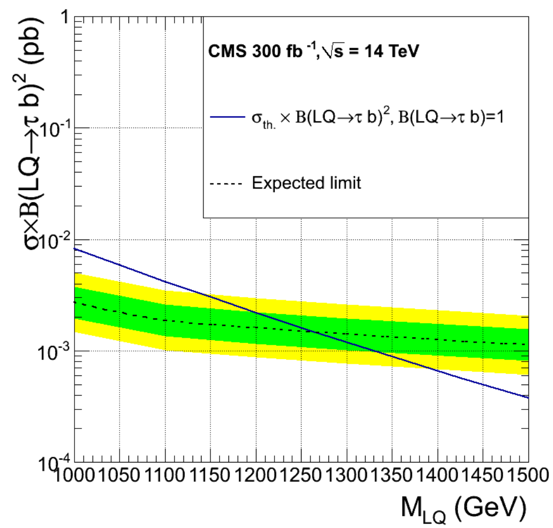
D0 – $\sqrt{s}$=1.96 TeV, 1.1 fb^{-1}



CMS – $\sqrt{s}$=7 TeV, 4.8 fb^{-1}



- Using asymptotic CLs and simple counting method yields ~1.3 TeV exclusion with 300 /fb



Further thoughts on these results

- Some improvements in the sensitivity is expected
  - Using S_T or M(τ ,b) for limits – yields ~20% better limit
  - Improve high p_T hadronic tau lepton and b-jet identifications
    - Decay products from τ or b-hadron are expected to be boosted if produced by heavy resonance decays: current reconstruction/ identification algorithms are optimized for objects with average momentum ranges – manifest some efficiency drop at high p_T region
  - Consider events with one b-jet requirement
    - Improve overall selection efficiency – crucial for higher mass signal hypothesis
  - More realistic PU expectation from new MC samples could change limits somewhat

Summary

- Preliminary studies for third-generation LQ sensitivity were presented for 300 fb^{-1} scenario at $\sqrt{s}$=14 TeV
- Further plans
  - Update study using parameterized simulation of background and signal samples to cover all luminosity/PU scenarios at $\sqrt{s}$=14 TeV and 33 TeV
  - Derive limits on
    - RPV decaying Stop for a given benchmark scenario
    - RPV LQD coupling λ'_{333} vs stop mass for a given μ or
    - μ vs stop mass e.g. for $\lambda'_{333} = 1, 0.1, 0.01$.
  - With minimal modification in the analysis, e.g. dropping the b-tagging requirement, we can also explore other RPV couplings λ'_{332} or λ'_{331}

BACKUP